Semi-Annual Report on NASA Grant NAGW5-1097:
MAMI:
Modeling of the Magnetosphere-Ionosphere-Atmosphere System.
1 November 1996 to 31 March 1997

- Software development to access and analyze level 1 UVI data has been developed and installed in close collaboration with the UVI team members. We have developed image processing software to transform UVI images into geographic and geomagnetic coordinate systems. We have developed procedures and provided software for separating dayglow and auroral brightness in UVI images. We also have software to interpret the images and ratios of images in different wavelength regions in terms of energy flux and characteristic energy of precipitating electrons. We contributed to a paper by the UVI team (Germany *et al.*, 1997a) describing this analysis technique (abstract appended).

- The period from 17:30 UT on 19 May, 1996, to 02:30 UT on 20 May, 1996 has been selected as a study period by the ground-based and theory teams. We have obtained data from the UVI imager, ground based magnetometers, incoherent scatter radars, HF radars (SuperDarn), DMSP satellites, and NOAA TIROS satellites. The data from these sources have been integrated into a consistent description of the ionosphere, using the AMIE technique. Our results were presented at the Fall AGU meeting (abstract is appended) and at the ISTP workshop January 7-9, 1997. We also maintain a special web page at URL

  `http://odin.gi.alaska.edu/~lumm/May_19_20/top.html`

  for this event and its analysis. Our ionospheric results are used to complement the global MHD modeling of this event. An article for publication in the Journal of Geophysical Research is in preparation.

- The CME event on 6 January and subsequent response of the magnosphere and ionosphere has attracted considerable attention (January 6-11, 1997 event). We have begun the analysis of UVI auroral images from this period which includes several auroral enhancements. Also available are ground based auroral observations. Unusual neutral winds in the thermosphere were observed at auroral latitudes at Poker Flat, Alaska. We anticipate that modeling this event with the AMIE and TIE-GCM models will provide insight into the coupling of the magnetospheric source to the neutral thermosphere. Initial results will be presented at the upcoming ISTP workshop (8-9 April, 1997). A web page for our analysis of this event has been established and is continually updated. It is accessible at URL:

  `http://odin.gi.alaska.edu/~lumm/Jan_6_11/`

- Local comparisons between *in situ* auroral flux and energy observations from DMSP and NOAA satellites and UVI image derived quantities have been utilized to assist the UVI team in validating the instrument calibration. We contributed to two papers submitted by the UVI team (Germany *et al.*, 1997b, 1997c) on these subjects (abstracts are appended).

- On 10 May, 1996, the Sondrestrøm radar and UVI images show good auroral activity. We have begun an analysis of this period with focus on comparisons of various parameters that are derived from radar observations and from auroral images.

- A paper comparing auroral data derived from UVI images and Sondrestrøm radar observations has been accepted for publication in the Geophysical Research Letters (Doe *et al.*, 1997). This comparison addresses auroral structures at the pixel resolution of the images.

Results from this study were also presented at the Fall AGU meeting. Abstracts of the GRL paper and the AGU meeting are appended.

- A paper comparing the integrated hemispheric energy flux derived from UVI images into the auroral zone with the hemispheric power from NOAA satellites has been accepted for publication in the Geophysical Research Letters (Lummerzheim *et al.*, 1997). This subject was also presented at the 1996 Fall AGU meeting in San Francisco. The abstracts of the GRL paper and AGU meeting are appended.
- The Fall AGU meeting in San Francisco (15-19 December, 1996) was attended by D. Lummerzheim, M. H. Rees, and R. G. Roble.
- The ISTP/GGS Science Team Meeting held at GSFC (7-9 January, 1997) was attended by D. Lummerzheim, M. H. Rees, and R. G. Roble.
- The home-page for MAMI on the World Wide Web at URL

  `http://loke.gi.alaska.edu/mami.html`

  is updated occasionally. This set of pages describes the theoretical background, modeling procedure, and gives a few examples using existing data. Recent additions include event pages for the May 19/20, 1996, and 6-11 January, 1997, analysis periods. We also maintain a list of publications on this web site.
- Submitted papers:

  D. Lummerzheim, M. Brittnacher, D. Evans, G. A. Germany, G. K. Parks, M. H. Rees, and J. F. Spann, High time resolution study of the hemispheric power carried by energetic electrons into the ionosphere during the May 19/20, 1996 auroral activity, *Geophys. Res. Lett.*, , *accepted*, 1997.

  R. A. Doe, J. D. Kelly, D. Lummerzheim, M. Brittnacher, G. A. Germany, G. K. Parks, and J. F. Spann, Initial comparison of POLAR UVI and Sondrestrøm IS radar estimates for auroral electron energy flux, *Geophys. Res, Lett.*, , *accepted*, 1997.

  Germany, G. A., G. K. Parks, M. Brittnacher, J. Cumnock, D. Lummerzheim, J. F. Spann, L. Chen, P. G. Richards, and F. J. Rich, Remote determination of auroral energy characteristics during substorm activity, *Geophys. Res, Lett.*, , *(submitted)*, 1997a.

  Germany, G. A., J. F. Spann, G. K. Parks, M. J. Brittnacher, R. Elsen, L. Chen, D. Lummerzheim, and M. H. Rees, Auroral Observations from the POLAR Ultraviolet Imager (UVI), AGU Monograph "Encounter Between Global Observations and Models in the ISTP Era", Jim Horwitz, Dennis Gallagher and Bill Peterson, editors, *(submitted)*, 1997b.

  Germany, G. A., G. K. Parks, M. J. Brittnacher, J. F. Spann, J. Cumnock, D. Lummerzheim, F. Rich, and P. G. Richards, Global Auroral Remote Sensing Using GGS UVI Images, AGU Monograph "Encounter Between Global Observations and Models in the ISTP Era", Jim Horwitz, Dennis Gallagher, and Bill Peterson, editors, *(submitted)*, 1997c.

Remote determination of auroral energy characteristics during substorm activity

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Submitted to Geophysical Research Letters

Abstract

Ultraviolet auroral images from the Ultraviolet Imager onboard the POLAR satellite can be used as quantitative remote diagnostics of the auroral regions, yielding estimates of incident energy characteristics, compositional changes, and other higher order data products. In particular, images of long and short wavelength N2 Lyman-Birge- Hopfield (LBH) emissions can be modeled to obtain functions of energy flux and average energy that are basically insensitive to changes in seasonal and solar activity changes. This technique is used in this study to estimate incident electron energy flux and average energy during substorm activity occurring on May 19, 1996. This event was simultaneously observed by WIND, GEOTAIL, INTERBALL, DMSP and NOAA spacecraft as well as by POLAR. Here incident energy estimates derived from UVI are compared with in situ measurements of the same parameters from an overflight by the DMSP F12 satellite coincident with the UVI image times.

SM21A-8 0830h POSTER

Comparing POLAR UVI imager data and other conductance sources in AMIE

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The Assimilative Mapping of Ionospheric Electrodynamics (AMIE) procedure requires information about the instantaneous distribution of ionospheric conductances in order to relate observed magnetic perturbations to the estimated pattern of high-latitude ionospheric electric fields. In the past, most of the conductance information for AMIE came from empirical models, locally modified by available observations of auroral precipitation from DMSP and NOAA satellites and by estimates derived from ground magnetometer data. Recently, POLAR UVI images using two filters have allowed estimates of auroral energy fluxes, mean electron energies, and associated Hall and Pedersen conductances over the entire northern auroral oval. For May 19-20, 1996, we compare the precipitation and conductance estimates derived from UVI data with those based on other data sources, as they influence the estimates of ionospheric electrodynamic parameters in AMIE. The UVI data result in larger estimates of the hemispheric power of precipitating auroral electrons, and hence larger conductances, as well as somewhat smaller polar-cap potential drops and reduced Joule heating. There are also considerable changes in the estimated nightside ionospheric currents and field-aligned currents.

Global Auroral Remote Sensing Using GGS UVI Images

G. A Germany, G. K. Parks, M. J. Brittnacher, J. F. Spann, J. Cumnock, D. Lummerzheim, F. Rich, and P. G. Richards

Submitted to AGU Monograph "Encounter Between Global Observations and Models in the ISTP Era", Jim Horwitz, Dennis Gallagher, and Bill Peterson, editors.

Abstract

The GGS POLAR satellite, with an apogee distance of 9 Earth radii, provides an excellent platform for extended viewing of the northern auroral zone. Global FUV auroral images from the Ultraviolet Imager onboard the POLAR satellite can be used as quantitative remote diagnostics of the auroral regions, yielding estimates of incident energy characteristics, compositional changes, and other higher order data products. In particular, images of long and short wavelength FUV LBH emissions can be modeled to obtain functions of energy flux and average energy that are basically insensitive to changes in seasonal and solar activity changes. The determination of maps of incident auroral energy characteristics is demonstrated here and compared with in situ measurements.

Auroral Observations from the POLAR Ultraviolet Imager (UVI)

G. A Germany, J. F. Spann, G. K. Parks, M. J. Brittnacher, R. Elsen, L. Chen, D. Lummerzheim, and M. H. Rees

Submitted to AGU Monograph "Encounter Between Global Observations and Models in the ISTP Era", Jim Horwitz, Dennis Gallagher, and Bill Peterson, editors.

Abstract

The Ultraviolet Imager, aboard the POLAR satellite, views the auroral zones with unprecedented spectral resolution in the far ultraviolet between 125.0 nm and 200.0 nm. Its ultraviolet imaging capabilities allow simultaneous observations of morphological changes in both sunlit and darkside auroral forms. The ability to spectrally isolate FUV emissions of interest permits quantitative analysis yielding remote estimates of magnetospheric and ionospheric parameters. The first year of the Ultraviolet Imager operation has been an exciting one with significant advancements in coordinated multiplatform studies at both apogee and perigee distances, dayside auroral observations, and the initial use of UVI images as remote quantitative probes of the auroral process. Here the capabilities and objectives of the Ultraviolet Imager are discussed. This is followed by a discussion of data analysis techniques with specific illustrative examples. Initial results of early investigations are presented to illustrate the capabilities and flexibility of this remote auroral monitor.

Initial comparison of POLAR UVI and Sondrestrom IS radar estimates for auroral electron energy flux

Richard A. Doe [1], John D. Kelly [1], Dirk Lummerzheim [2], George K. Parks[3], Mitchell J. Brittnacher[3], Glynn Germany[4], and James Spann[5]

Abstract. Calibrated images from the POLAR satellite ultraviolet imager (UVI) in the 165.5 to 174.5 nm portion of the N_2 Lyman-Birge-Hopfield band (LBH-long) can be used to estimate the energy flux (F_E) of auroral electrons precipitating into the high-latitude ionosphere. Similarly, electron density profiles, as measured by ground-based incoherent-scatter (IS) radar, can be used to estimate F_E and mean energy (E_0) by solving a system of linear equations relating the *E*-region ionization rate profile to a family of monoenergetic ion production profiles. A coordinated POLAR/IS radar experiment, designed as an initial comparison of POLAR UVI and ground-based estimates of F_E for a stable auroral arc, was executed during a POLAR apogee on May 20, 1996 at the Sondrestrom IS radar facility (lat. 66.99° N, long. 50.95° W). Reconstructed energy distributions, based on radar-measured N_e profiles, indicate an approximately 2 keV Maxwellian source with an energy flux of from 6.4 to 14 mW m^{-2}. LBH-long images, binned over 0.5° of latitude and 1.0° of longitude, were used to derive energy flux as well. The UVI-derived F_E time history agrees favorably with radar estimates both in absolute magnitude and in the trend for this period. This experiment suggests that reliable estimates for the precipitating electron source energy and its ionospheric response can be derived from either ground-based IS radar or POLAR UVI images during summertime conditions.

SM22D-10 1620h

Comparison of POLAR UVI and Sondrestrom IS Radar Estimates for Auroral Precipitation Energetics

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Auroral UV images from the POLAR satellite in the LBH N_2 band can be used to estimate the mean energy (E_0) and the energy flux (Q) of electrons precipitating into the ionosphere and, by use of an electron transport model, can be used to estimate the shape of the electron density profile ($N_e(z)$). Similarly, E-region electron density profiles, as measured by the Sondrestrom ground-based incoherent scatter (IS) radar (66.99 N Lat, 50.95 W Lon), can be used to reconstruct the source energy distribution using the deconvolution method of *Vondrak and Baron* [1976]. Such reconstructed energy distributions can be fit with analytic functions to recover estimates for E_0 and Q. A coordinated POLAR UVI/Sondrestrom IS radar experiment, designed to cross-compare estimates E_0, Q, and N_e, was executed during a POLAR apogee on May 20, 1996. During this experiment, a stable recovery phase arc was detected in UVI LBH-short and LBH-long images, as well as in Sondrestrom elevation scans and up-B dwells. IS radar estimates for E_0 and Q based on three consecutive N_e profiles (0232:50 UT to 0244:42 UT) compare well with POLAR UVI estimates, despite the somewhat coarse (0.5°) latitudinal resolution of the UVI PIXELS. POLAR UVI estimates for the shape of the N_e profile, based on the electron transport model of *Lummerzheim and Lilensten* [1994], compare favorably with IS radar $N_e(z)$ measurements as well. Implications for the calculation of conductance from such 2-band LBH images will also be discussed.

Lummerzheim, D. and J. Lilensten, Electron transport and energy degradation in the ionosphere, *Ann. Geophys., 12,* 1039, 1994.

Vondrak, R. R. and M. J. Baron, Radar measurements of the latitudinal variation of auroral ionization, *Radio Sci., 11,* 939, 1976.

To appear in the *Geophysical Research Letters* special edition on ISTP/GGS

High Time Resolution Study of the Hemispheric Power Carried by Energetic Electrons into the Ionosphere During the May 19/20, 1996 Auroral Activity

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Abstract

The ultraviolet imager (UVI) on board the POLAR satellite offers the opportunity to obtain high time resolution global auroral images. The spectral discrimination of the imager is sufficient to separate the auroral far ultraviolet emissions from the scattered sunlight, even when the entire auroral zone is sunlit. The energy flux of the precipitating electrons is derived from the surface brightness through the LBH-long filter. Global images which have the dayglow removed are spatially integrated to yield the total rate of energy input into the northern hemisphere. This parameter, the hemispheric power, has found much application in ionospheric modeling. It can also be derived from electron spectra measured along the track of the NOAA/TIROS satellites that are combined with average empirical auroral precipitation patterns. We show that the hemispheric power derived from the two-dimensional images represents a substantial improvement in the temporal variability of this parameter. We present an example for the period of 19/20 May 1996 by comparing the hemispheric power derived from NOAA/TIROS measurements with those derived from the UVI images.

SM21A-7 0830h POSTER

High Time Resolution Hemispheric Power Derived from POLAR Imager Data

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The UVI imager on board the POLAR satellite offers the opportunity to obtain high time resolution global auroral images. The spectral resolution of the imager is sufficient to separate the auroral emission from the scattered sunlight, even when the entire auroral zone is sunlit. The brightness observed by one of the filters (LBH-long) can be interpreted in terms of energy flux of the precipitating electrons. Global images which have the scattered sunlight removed can be integrated to provide the total hemispheric electron energy flux. This parameter, the hemispheric power index, has in the past found much application in ionospheric modeling. It can also be derived from *in situ* measurements of the electron energy flux aboard the NOAA-TIROS or DMSP satellites in combination with average auroral precipitation patterns. We show that the image data provide a substantial improvement over the *in situ* measurements and present an example for the period of May 19 and 20, 1996, comparing data from NOAA-TIROS with UVI images.